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VENTILATION, WEATHER AND THE COMMON COLD

A Study of the Prevalence of Respiratory Affections Among School Children and Their Association with School Ventilation and the Seasonal Changes in Weather

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VENTILATION, WEATHER, AND THE COMMON COLD *

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INTRODUCTORY

DURING the last twenty years there has been a great amount of experimental work on ventilation and its effect on the body. Workers in Europe and the United States are in substantial agreement that it is the thermal factors—temperature, air motion and humidity—which exercise the greatest influence on human comfort, health and efficiency. The chemical composition of the air we ordinarily breathe—leaving out of consideration for the moment those special industrial problems involving gases, fumes and dusts—is of relatively little moment in its effect on human conduct. School children are far better off in a cool, airy room, regardless of the carbon dioxide content of the air, than they are in air virgin pure chemically which is overheated.

It is most important that the facts as we have stated them should be clearly understood, for otherwise, there is bound to arise, as there has in the past, a misunderstanding as to the suitability of different methods of ventilating school buildings.

If variable, as opposed to uniform, temperature, air motion and humidity are desirable factors, then very satisfactory conditions can be maintained in school rooms by ventilating with the windows, protected by deflectors, and an exhaust duct on the opposite side of the room, heating being by direct radiation beneath the windows. This method of ventilating will not always give good aeration. At times the room will be amply flushed with outside air. At other times, due to shifting winds, the circulation will be lessened, the room will not be thoroughly flushed, and the carbon dioxide content will rise, indicating an accumulation of the products of exhalation and body vaporization. Even though the aeration of the room fluctuates, it is possible to have coolness at all times and variability, and if the room is cool and

*This is an abridged form of a dissertation presented in partial fulfillment of the requirements for the degree of Doctor of Public Health at the University of Michigan, 1920.

This study was conducted jointly by the Bureau of Child Hygiene of the New York City Department of Health, represented by Dr. S. Josephine Baker, Chief of the Bureau, and the New York State Commission on Ventilation, represented by the author, who then held the position of chief of the investigating staff. The collection of sickness records and the taking of temperature and other observations on air conditions was done by nurses and physicians of the Health Department under the supervision of Drs. L. Marcus and R. H. Willis. The routine clerical work of tabulation was likewise conducted by the Health Department under the immediate direction of Dr. Franklin Van Wart. The planning of the investigation, selection of schools, initial instruction of the field staff and the final analysis and interpretation of results is largely the work of the author.

variable within certain limits it makes little practical difference as to the humidity.

On the other hand, if the experimental data of the last two decades are wrong in minimizing the relative value of chemical purity of the atmosphere, then window ventilation as we have described it is inadequate, and it will be necessary to insure at all times voluminous and continuous flushing of the room with outside air. This can be done only by mechanical means, that is by plenum fans or blowers.

There has existed for some time a controversy as to the relative merits of natural and mechanical ventilation. An inheritance from the days of Pettenkofer, when chemical purity was regarded as vital, has kept alive the carbon dioxide content as the standard of ventilation goodness. This standard persists to this day. Measured in these terms the window ventilated room falls into disrepute. A carbon dioxide standard of 6 to 10 parts per 10,000 automatically throws any form of window ventilation into the discard. It is only by mechanical means that this degree of chemical purity can be at all times assured.

With the development of mechanical ventilation there has grown up an impression that uniformity in temperature, in air motion and in humidity is ideal, and again the mechanically forced ventilation far excells the gravity method in this respect. Furthermore the dust in outside air can be removed readily under the mechanical system by the introduction of air washers. This is not possible with window ventilation.

There is much then that can be accomplished with the plenum system that is not possible under the window method. The question arises as to whether the superiority of the mechanical system is superficial, a matter of a relatively unimportant refinement so far as the school classroom is concerned. The drawbacks to the mechanically ventilated classroom are its tendency to overheating, its unstimulating uniformity and its greater expense.

There is much to be said on both sides. The advocates of window ventilation are impressed by its success with tuberculously inclined and undernourished children. It has a wide application in our public schools at the present time. If good for sick children, why not for well children? Is window ventilation in the schoolroom to be ruled out of consideration merely because it fails to live up to the carbon dioxide standard? It was for the purpose of testing out these principles on a practical scale that the present experiment was undertaken. After all, the proof of the pudding is in the eating. If the health of school children, as measured by the amount of respiratory illness, such as colds, tonsillitis, etc., is better under the more elaborate systems of mechanical ventilation, then let us proceed to equip our buildings in this manner. If, on the other hand, the mechanical ventilating equipment does not supply substantial benefits to the health, comfort or efficiency of our school child population, or is actually inferior in the things that count for health, let us face the matter squarely.

There are innumerable demands for public funds. If we are paying out vast sums of money for benefits which are not real but imaginary, recognition

of this fact cannot come too soon. If window ventilation provides the important essentials of a healthy atmosphere in a way that cannot be attained or improved upon by mechanical systems of indirect ventilation, then our school buildings should be built accordingly, and we should not hesitate because a worn out standard of ventilation dictates otherwise.

During the latter part of 1916, from February 14th to April 6th (8 weeks), and the winter of 1916-17, from October 30 to January 26 (12 weeks), observations were made on the health of 5500 New York City school children who were exposed to various types of ventilation in 12 different school buildings. In general these ventilation systems may be classified under three main headings, as follows:

A—Cold, open window rooms, gravity exhaust.

B—Cool, window ventilated rooms, gravity exhaust.

C—Plenum, fan ventilated rooms with gravity exhaust and with windows closed.

As an index of health, the sickness records of the pupils were used. The condition of the air was determined by readings of temperature and humidity and by the personal sensations of the observers as to temperature, moisture, air motion and odor. It would have been desirable to determine also the carbon dioxide content of the air, but this involved analytical work which the staff was unable to do. The absence of these latter data was not serious, however, for the Ventilation Commission had available a mass of data on this subject collected over two years' time, and it was well established that the carbon dioxide content of fan ventilated rooms averages several parts lower than in window ventilated rooms.

For the convenience of the reader we shall reserve the description of working methods and ventilation types in individual schools for the later pages and shall proceed with an account of the findings of this study.

RESULTS OF SICKNESS SURVEY IN DIFFERENT TYPES OF VENTILATED SCHOOL ROOMS

The first half of the study in the spring of 1916 covered 2500 pupils in 58 classrooms distributed among 8 schools. The second half in the winter of 1916-17 was represented by 3000 pupils in 76 classrooms in 12 schools.

In both studies the absences due to respiratory illness and the respiratory illness among pupils present in school was greatest in the fan ventilated rooms, Type C. This is the result after combining all records and disregarding in this instance the balancing of the type of pupil, location of school, etc., which will be treated more at length later on.

The excess of respiratory illness in the Type C rooms holds good both for absentees and those in school. The total illness is least in the second group, or cool, window ventilated rooms. The difference, however, between the first and second types of window ventilation is less than between either the first or second and the third. In other words, assuming for the moment that these differences are due to atmospheric influences, the air conditions in the first two types do not produce greatly divergent effects, but the influences at work in the third type are distinctly less favorable.

The significance of these two sets of results may be expressed in this manner; for every 100 cases of respiratory illness in the cool window ventilated rooms, there are 152 in cold, window ventilated rooms, and 231 in fan ventilated rooms.

TABLE I

RESPIRATORY ILLNESS PER 1000 REGISTRATION (PUPIL-SESSION) UNITS*

Ventilation Type	FIRST STUDY Among Absentees	FIRST STUDY Among Pupils in School	FIRST STUDY Total	SECOND STUDY Among Absentees	SECOND STUDY Among Pupils in School	SECOND STUDY Total
A-Cold, Window Rooms	10.6	37.2	47.8	9.2	75.3	84.5
B-Cool, Window Rooms	10.2	22.1	32.3	10.7	44.1	54.8
C-Fan Ventilated	14.2	76.0	90.2	13.0	98.4	111.4

TABLE II

BASIC FIGURES FROM WHICH RATES IN TABLE I ARE COMPUTED

Ventilation Type	FIRST STUDY Total Registration Units	FIRST STUDY Total Absence Units due to Respiratory Illness	FIRST STUDY Total Units of Respiratory Illness among Pupils in Attendance	SECOND STUDY Total Registration Units	SECOND STUDY Total Absence Units due to Respiratory Illness	SECOND STUDY Total Units of Respiratory Illness among Pupils in Attendance
A	61,658	655	2,298	89,067	822	6,705
B	71,231	728	1,578	113,959	1,218	4,661
C	65,088	925	4,950	115,215	1,497	11,329

The actual temperature conditions found in the three types of rooms are disclosed in the two tables following, in one of which results are expressed as averages, and in the other by temperature groups.

TABLE III

AVERAGE OF ROOM TEMPERATURES

Ventilation Type	First Study	Second Study	Mean
A	58.8	59.1	59.0
B	66.9	65.9	66.4
C	68.8	67.9	68.4

*The unit of illness was one pupil per half-day school session. Illness is reported in pupil session units. One pupil ill ten sessions counted the same as ten pupils ill one session. A pupil was continued on the register regardless of the length of absence from school unless it was found that the family had moved away from the school district, or that the pupil had left school permanently.

Separate tabulations have been made of illness resulting in absence from school and illness among pupils who continued to attend school. The absences are classified as (1) absence from respiratory illness, including coryza, bronchitis, pharyngitis, laryngitis, tonsillitis, pneumonia, tuberculosis and a miscellaneous group variously termed grippe, colds, sore throat, etc.; (2) absence from illness other than respiratory, namely: stomachache, backache, broken leg, etc. In this group were also the acute infectious diseases such as diphtheria, measles, scarlet fever, whooping cough, chickenpox, mumps, etc. This was done because it was felt that the spread of these infections was largely determined by specific susceptibility rather than by atmospheric influences; (3) absence due to causes other than illness, such as staying at home to mind the baby, going on a visit, shopping with parents, truancy, etc.

The fan ventilated or Type C rooms averaged but two degrees higher than those of Type B and nearly ten degrees warmer than Type A. Type A was extremely cold for a school room. Type B was cooler than is customarily found. The average temperature of Type C, though higher than B, was not exceptionally high.

There was a wide range in the daily temperatures, which are lost sight of in the averages.

TABLE IV

FREQUENCY DISTRIBUTION OF TEMPERATURES
PER CENT OF SESSIONS

Types Ventilation	59° and below	60-69°	70° and over
	1st Study		
A	56	41	3
B	5	61	34
C	4	57	39
	2nd Study		
A	46	48	6
B	8	88	4
C	0.2	99	0.8

The A rooms rarely reached 70°. Fully half of the sessions were below 59°. The B and C rooms rarely fell below 60°. The temperatures in the second study were much more uniform, particularly as regards Type C and to a lesser extent Type B. More than one-third of the sessions in B and C in the first study were above 70°. Much of this represented an overheated condition. However, the first study was made in the late winter, when greater outdoor variation is experienced than from November to January. Although the proportion of sessions between 60 and 70° does not appear to differ much in the B and C rooms, yet there was an appreciable difference within this range. Thus, in the first study 24 per cent of sessions in B were from 60° to 64°, whereas but 6 per cent of the sessions in C were within this range. Thirty-seven per cent of B sessions were from 65 to 69 as against 51 per cent of the C sessions. The C rooms were warmer, as the averages have already indicated.

The interesting point to be noted is that whereas there was but two degrees difference in temperature between the B and C rooms, there was a wide difference in the sickness rates. Between 7 and 8 degrees separated Types A and B, and yet in spite of this the sickness rates were quite similar. Evidently some factor other than temperature operated differently on these three classes of rooms or else a rise of two degrees above 66° is far more conducive to colds than a drop of as much as 7 degrees.

HUMIDITY

The relative humidity ranged from 38 to 46% and did not differ greatly in the three classes.

As would be expected, the relative humidity was higher in the colder rooms. With the same amount of moisture present as in Type A, the relative humidity in the first study at the temperature in Type B would be 33.4,

Table V

Relative Humidity

Ventilation Type	First Study	Second Study
A	43.7	46.3
B	37.8	43.0
C	37.8	41.2

and in Type C 31.4. The corresponding figures in the second study would be 29.9 for B and 28.7 for C. It would appear, therefore, that there was an accumulation of moisture in the Type B rooms, and this could only come from reduced aeration. In Type C the same explanation would hold. The rooms at P. S. 59 were humidified, as were also the rooms at P. S. 51 and 97, but this would hardly affect the average of all rooms in the group to this extent. It is also possible that the taking of the humidity reading was not as accurately done in the dry rooms, the wet bulb being read before the mercury column had completed its fall. These readings are higher than we should expect at this season of the year, judging from records taken by the Commission in similar rooms in other schools.

Other indices of air conditions were the opinions of the nurses who visited the rooms at least twice daily.

FRESHNESS AND ODOR

The results of the nurses' votes on the freshness or lack of freshness and presence of odor in the rooms are given in Table VI.

Table VI

Ventilation Type	Percentage of Sessions Judged: Exceptionally Fresh	Odor Absent but not Exceptionally fresh	Odorous
	First Study		
A	62	24	14
B	25	57	18
C	21	64	15
	Second Study		
A	69	28	3.2
B	18	62	20
C	22	67	11

The results are very interesting from several points of view. The Type B rooms are most odorous in both studies. The excess over the others was slight in the first study, 18, as compared to 15 for Type C and 14 for A. It was more marked in the second study, 20, as against 11 for C and only 3.2 for A.

The freshest rooms are the coldest rooms. Sixty-two per cent of the sessions in Type A in the first study were judged exceptionally fresh, and in the second study the figure was 69 per cent. The figures for Type B were 25 per cent in the first and 18 in the second. Type C had 21 per cent in the first and 22 per cent in the second.

What seems clear from these figures is that to be exceptionally fresh the greater part of the time, rooms must be well below 65 degrees in temperature. Warmer rooms may be free from odor and yet exceptionally fresh not much over one-fifth of the time.

In rooms that did not differ greatly in temperature, as B and C, the greater aeration produced by fan ventilation reduced odor to a slight degree in the first study, and to a marked degree in the second. It failed to make the rooms any fresher in the first study, but did help out in the second study.

Although we do not possess complete records of the carbon dioxide content, there is little doubt but that the smallest amount would be found in the fan ventilated rooms, Type C, as we have already pointed out. Repeated records collected in three schools show this tendency (Table VII).

TABLE VII

CARBON DIOXIDE IN PARTS PER 10,000

SCHOOL	VENTILATION TYPE	
	B	C
33	6.9	5.5
115	7.6	6.5
97	8.6	5.7

The markedly greater freshness of the Type A rooms is due, without question, to their low temperature, and not because of the greater chemical purity of the air. Freshness is not a question of odor, for the Type B rooms were fresher than C and yet more odorous.

SENSATION OF TEMPERATURE

The recorded votes of the nurses as to whether the temperature of the rooms felt "too cool," "satisfactory" or "too warm" are given in Table VIII.

TABLE VIII

VENTILATION TYPE	PER CENT OF SESSIONS JUDGED		
	TOO COOL	SATISFACTORY	TOO WARM
	First Study		
A	7.9	77	16
B	6.2	78	16
C	10	76	14
	Second Study		
A	26	70	3.9
B	8.6	80	11
C	3.6	85	12

In the first study the per cent of satisfactory sessions was about the same in all three types, being in the neighborhood of 77 per cent. There were more sessions judged "too warm" in Types A and B than in C, although the average temperature was lower than C. The "too cool" sessions were most numerous in Type C, the rooms of highest temperature. In other words, the coldest rooms felt warmer than the warm rooms. In view of the actual temperature found, it would appear that the nurses were influenced in their judgment of what the

temperature should have been rather than by actual sensation. In no other way can we account for the votes in rooms whose temperature differed by at least ten degrees, as was the case in Types A and C.

The votes in the second study more nearly reveal the actual temperature condition as indicated by the thermometer. In A 26 per cent of the sessions were judged "too cool." In fact, 4 per cent were voted "too cold"—an extreme condition. In Type B, 8.6 per cent were "too cool" and in C 3.6 per cent.

Type C had the greatest number of sessions judged satisfactory as to temperature; namely, 85 per cent. The corresponding figure for Type B was 80 and for A, 70.

Too great warmth was experienced 12 per cent of the time in C, 11 per cent in B and but 3.9 per cent in A.

The sensation of temperature reflects the actual thermometer reading—to some extent at least. There was much lesss overheating in the second study, and this agrees with the lesser number of "too warm" votes.

SENSATION OF MOISTURE

As will be seen from the figures given below, over 80 per cent of sessions in all three types of the first study were judged satisfactory as to moisture. Both moisture and dryness were most pronounced in Type C.

TABLE IX

VENTILATION TYPE	PER CENT OF SESSIONS JUDGED MOIST	SATISFACTORY	DRY
	First Study		
A	5.9	88	6.7
B	1.7	89	9.0
C	7.3	83	9.7
	Second Study		
A	33	66	0.6
B	20	74	6.4
C	8.5	84	7.9

The second study reveals a greater divergence between the rooms. Type C had the highest percentage of satisfactory sessions, 84. Type B had but 74 per cent and Type A, only 66. The cooler sessions are associated with moisture, the warmer sessions with dryness. One-third of all sessions in A were moist and less than 1 per cent dry. Twenty per cent of sessions in B were moist and 6.4 per cent dry. Eight and five-tenths per cent of C were moist and 7.9 per cent dry.

There was less overheating in the second study and the sensation of dryness is less. Type C is similar in both studies. The other two types are different in that the second study shows many more moist sessions.

AIR MOTION

The greatest proportion of satisfactory votes as to air motion was found in A. Moving air was noticed most frequently in A and least in B. The results

of both studies are similar, although it is surprising to find the sessions in Type C judged "dead" to be more numerous in the second study where the air flow through the rooms was greater and the temperature was lower.

TABLE X
PER CENT OF SESSIONS JUDGED

VENTILATION TYPE	DEAD	SATISFACTORY	BREEZY
	First Study		
A	4.7	81	14
B	15	78	7.1
C	9.3	73	18
	Second Study		
A	9.2	74	17
B	18	75	7.0
C	23	68	9.8

ANALYSIS OF SICKNESS RATES IN INDIVIDUAL ROOMS AND SCHOOLS

AS we have pointed out in the introductory remarks, great care must be taken in drawing conclusions as to the correlation of different facts from the average results of a group. In the study before us it will be necessary to inquire into the records of each school and of the individual rooms to see whether they agree uniformly with the characteristics of the group.

In Tables XI and XII are assembled records for each room covering the nature of air conditions and the amount of respiratory sickness.

It is noticeable that there is a wide variation in respiratory illness. Room 415 (Type B) at P. S. 22 in the second study had no absences whatever from respiratory illness. Room 311 (Type C), P. S. 115, in the second study, has a rate of 50.4. These represent the minimum and maximum limits. The range of respiratory sickness-in-attendance rates is even greater—from zero to 316.

Room 311, P. S. 59 (Type A) is the most congested in the first study, there being but 6.5 square feet of floor space per pupil. In spite of this crowded condition, the absence rate from respiratory disease is only 0.6—one of the lowest. On the other hand, Room 202, P. S. 165, being the least congested, with 19.6 square feet per pupil, has a respiratory absence rate of 37.0, a very high figure. Overcrowding does not inevitably lead to respiratory illness.

The average temperature of Type A rooms was about 59 degrees in both studies. This is much colder than the ordinary school room. In fact, it seems from our general experience entirely too cold for public school children, and yet, on looking over the absence rates, there is no indication that these children had more colds as a result. In fact, the average absence rate for the entire group is lower than the other two ventilation types, as has already been pointed out. In the first study there are only two rooms in Type A with rates over 20. There are three each in Types B and C. Respiratory sickness among those present in school is greater in Type A than in B, but less in A than in C.

In spite of the well intentioned efforts to balance the three types of rooms in the matter of schools and type of pupil, this could not be carried out to

TABLE XI

RECORDS OF INDIVIDUAL ROOMS IN FIRST STUDY

SCHOOL	ROOM	RESPIRATORY SICKNESS RATES			AV. TEMP.	AV. REL. HUMIDITY	PER CENT SESSIONS		PER CENT GIRLS	GRADE	SQ. FT. OF FLOOR SPACE PER PUPIL
		AMONG ABSENTEES	AMONG THOSE IN ATTENDANCE	TOTAL			ESP. FRESH	ODOROUS			
Type A—Cold Open Window Rooms											
12	303	15	9.6	24.6	61.7	45	87	1	49	3A	15.5
	409	8.6	3.1	11.7	59.5	45	95	0	100	4B	13.5
	410	5.0	16.0	21.0	60.3	43	81	0	100	4B	13.8
39	202	11	0	11.0	56.9	52	96	1	0	3A	18.9
	203	14	.6	14.6	57.4	46	96	1	0	4A	13.6
	204	14	0	14.0	57.5	50	92	1	0	3B	15.1
	205	21	2.4	23.4	56.8	47	93	0	0	3B	15.0
	206	17	1.8	18.8	57.5	48	94	3	0	5A	14.4
	207	11	1.7	12.7	56.9	45	96	1	0	4B	11.7
59	311	.6	21.0	21.6	59.0	38	28	9	27	3B	6.5
	313	8.2	210	218.2	57.7	38	86	13	5	2B	9.9
	412	5.8	91.0	96.8	58.6	37	27	73	98	4A	6.9
	413	8.5	72.0	80.5	61.4	37	3	8	73	4B	7.8
	414	.6	74.0	74.6	57.1	37	30	6	60	4A	7.8
73	301	6.4	33.5	39.9	57.8	47	39	27	47	5A	9.4
	309	10.8	42.4	53.2	56.3	44	51	21	46	3A	8.4
	402	25.8	72.0	97.8	62.2	45	17	71	57	6A	9.9
	403	11.5	31.6	43.1	64.0	46	3	88	67	5B	9.2
Type B—Moderate Temperature, Open Window Rooms											
2 Bx.	301	3.1	35.7	38.8	70.7	25	25	8	0	4B	12.3
	302	31	38.4	69.4	70.7	25	16	4	48	3B	11.9
	316	16.4	46.5	62.9	69.7	24	29	9	100	5A	12.3
12	405	4.5	14.8	19.3	66.5	43	36	3	35	3B	13.6
	408	11.3	13.5	24.8	67.5	42	44	0	100	3B	13.1
	411	5.1	17.0	22.0	65.9	44	40	1	100	4A	13.8
22	415	3.7	7.4	11.1	69.9	45	9	8	44	5B	8.1
	416	8.5	6.5	15.0	69.7	48	5	30	23	4B	7.9
	418	8.0	0	8.0	69.3	43	13	3	0	5A	7.8
39	302	6.9	0	6.9	62.2	40	80	1	0	3B	14.9

TABLE XI (CONTINUED)

SCHOOL	ROOM	RESPIRATORY SICKNESS RATES: AMONG ABSENTEES	RESPIRATORY SICKNESS RATES: AMONG THOSE IN ATTENDANCE	RESPIRATORY SICKNESS RATES: TOTAL	AV. TEMP.	AV. REL. HUMIDITY	PER CENT SESSIONS: ESP. FRESH	PER CENT SESSIONS: ODOROUS	PER CENT GIRLS	GRADE	SQ. FT. OF FLOOR SPACE PER PUPIL
39	308	21	.6	21.6	60.2	45	88	1	0	3A	13.4
	403	1.4	0	1.4	62.3	45	65	4	0	4A	12.7
59	318	15.1	60.9	76.0	64.8	36	5	6	56	2B	7.5
	411	10.9	90.6	101.5	65.7	32	12	13	100	5A	8.7
	416	1.5	14.6	16.1	65.6	32	4	12	7	4A	7.2
73	305	3.2	1.1	4.3	66.8	46	0	41	51	4A	11.1
	406	10.2	1.2	11.4	62.8	43	13	35	64	3B	12.0
	408	10.4	23.9	34.3	66.4	47	0	56	56	5A	9.5
165	302	10.4	21.3	31.7	69.4	30	21	3	0	5B	16.5
	306	5.7	37.9	43.6	67.7	33	26	3	0	4B	15.1
	309	26.4	47.5	73.9	71.8	27	6	21	0	4B	11.1
			Type C—Moderate Temperature, Fan Ventilated, Closed Window Rooms								
2 Bx.	207	13.0	64.2	77.2	69.5	30	26	18	0	3A	12.2
	307	.8	32.7	33.5	68.6	25	39	15	0	4A	18.6
	310	13.3	47.2	60.5	69.2	24	64	6	0	5A	13.8
22	402	7.0	4.1	11.1	68.4	42	11	3	100	4B	12.9
	403	10.5	12.0	22.5	67.4	46	14	1	100	4B	13.3
	404	8.9	25.4	34.3	68.5	43	14	3	100	4A	12.4
59	304	16.9	188	204.9	68.5	48	23	15	100	5A	14.0
	401	17.9	149	166.9	68.9	47	19	23	100	5A	15.2
	405	16.8	140	156.8	67.8	49	31	10	100	4B	14.2
	501	10.4	163	173.4	67.8	50	19	24	100	5B	14.0
	503	8.0	96.6	104.6	68.3	50	47	3	100	5B	13.5
	505	12.6	97.3	109.9	68.0	50	37	3	100	5B	14.5
147	210	8.4	45.8	54.2	66.4	38	3	28	41	3A	15.4
	304	1.5	72.5	74.0	68.0	36	9	47	47	4B	15.1
	305	9.6	21.5	31.1	67.5	36	8	26	39	5A	18.5
165	201	34.0	33.6	67.6	70.2	30	3	9	34	4A	15.3
	202	37.0	81.8	118.8	72.2	24	0	10	45	3B	19.6
	220	35.2	156.0	191.2	70.8	24	4	6	36	4A	16.8
	308	12.0	33.6	45.6	70.5	27	11	22	0	5B	12.0

TABLE XII

RECORDS OF INDIVIDUAL ROOMS IN SECOND STUDY

SCHOOL	ROOM	RESPIRATORY SICKNESS RATES PER CENT: AMONG ABSENTEES	AMONG THOSE IN ATTENDANCE	TOTAL	AV. TEMP.	AV. REL. HUMIDITY	ESP. FRESH	ODOROUS	GRADE
				Type A—Cold Open Window Rooms					
12	303	3.9	46.6	50.7	59.9	58.0	28	0	2 A
	409	8.1	13.7	21.8	61.3	54.4	18	0	4 B
	410	11.1	14.2	25.3	60.3	56.0	33	0	4 B
39	202	6.9	65.0	71.9	58.7	41.3	65	4	3 A
	203	13	40.0	53.0	56.2	43.4	72	2	4 A
	204	21.6	45.9	67.5	56.6	43.1	72	1	3 B
	205	6.7	30.3	37.0	58.7	42.2	46	7	3 B
	206	9.3	24.9	34.2	58.3	40.3	55	0	3 A
	207	11.7	18.4	30.1	57.6	41.4	60	2	4 B
59	308	4.0	165	169	60.0	48.0	100	0	3 B
	311	8.5	144.	152.5	58.5	48.9	100	0	3 A
	313	26.8	213	239.8	59.0	44.7	85	11	2 A
	412	4.3	150	154.3	58.1	45.1	100	0	4 A
	413	9.2	147	156.2	60.0	48.0	98	2	4 B
	414	3.0	124	127	57.8	48.4	100	0	4 A
	416	8.0	91.3	99.3	57.6	46.5	100	0	4 B
73	301	5.1	44.1	49.2	60.2	44.8	71	2	5 B
	309	11.6	34.8	46.4	58.9	45.9	67	2	4 A
	402	6.1	18.4	24.5	60.5	44.7	72	5	6 A
	403	6.2	39.4	45.6	63.5	45.3	50	29	5 B
				Type B—Moderate Temperature, Open Window Rooms					
2 Bx.	301	10.7	9.7	20.4	68.6	38.5	0	13	2 B
	302	7.7	5.8	13.5	69.0	38.5	0	23	2 B
	316	11.6	12.2	23.8	65.4	40.0	0	24	5 A
12	405	9.5	33.2	42.7	62.2	57.8	6	1	4 A
	408	15.9	31.4	47.3	63.5	59.0	1	2	3 B
12	411	9.9	5.8	15.7	63.8	60.6	3	10	4 A
22	415	0	0	0	67.6	57.7	17	82	5 B
	416	5.5	2.7	8.2	68.2	56.0	23	72	6 A
	418	.9	24.6	25.5	67.3	56.7	29	65	5 B
33 Bx.	13	21.4	55.7	77.1	69.3	31.3	0	9	8 B
	23	27.5	47.5	75.0	69.4	37.2	1	21	7 A
39	302	10.9	33.6	44.5	63.0	40.3	19	0	4 A
	308	8.6	42.8	51.4	65.0	37.7	23	3	5 A
	408	2.9	58.0	60.9	65.2	39.0	9	31	5 A
59	318	3.7	187	190.7	64.9	48.5	4	61	3 A
	415	16.2	158	174.2	58.8	48.2	100	0	4 B
73	305	9.7	23	32.7	61.6	46.5	45	10	4 B
	406	2.7	41	43.7	67.1	43.3	17	35	3 A
	408	16	51	67	61.1	43.6	74	4	3 B
97	302	6.4	37	43	67.0	38.2	17	62	5 B
	313	7.1	50	57	67.3	41.8	71	17	4 A
	501	3.0	55	58	65.9	44.8	59	18	6 B
115	312	23.3	—	—	67.8	28.8	3	3	4 B
	502	40.2	—	—	67.9	26.2	2	3	5 B

TABLE XII (CONTINUED)

SCHOOL	ROOM	RESPIRATORY SICKNESS RATES: AMONG ABSENTEES	AMONG THOSE IN ATTENDANCE	TOTAL	AV. TEMP.	PER CENT SESSIONS: AV. REL. HUMIDITY	ESP. FRESH	ODOROUS	GRADE
	503	29.8	—	—	67.0	29.5	0	3	5 B
165	302	1.3	99	100.3	67.2	35.9	0	0	5 B
	306	10.4	56	66.4	66.8	35.7	0	0	4 B
	309	8.1	33	41.1	68.9	36.1	0	0	4 B
	Type C—Moderate Temp., Fan Ventilated, Closed Window Rooms								
2 Bx.	207	22.4	25.5	47.9	66.1	39.6	0	13	2 A
	307	13.2	17.0	30.2	65.8	41.2	0	35	3 B
	310	1.3	3.8	5.1	66.5	41.5	0	20	4 B
22	402	4.8	5.6	10.4	66.5	57.0	75	16	6 A
	403	3.5	1.3	4.8	65.8	56.2	77	23	4 B
22	404	14.4	18	32.4	66.5	54.9	66	17	4 B
33 Bx.	14	29.3	23	52.3	71.0	28.6	1	2	6 B
	24	45.4	125	170.4	70.2	32.0	3	3	5 A
51 Bx.	203(Hum.)	4.0	148	152	67.6	43.6	0	39	6 A
	205	14.7	50	64.7	67.4	29.0	0	2	6 A
59	203	16.8	182	198.8	69.2	47	10	12	6 B
	205	13.9	275	288.9	69.2	45.5	17	5	6 B
	206	9.9	316	325.9	69.6	46	16	1	6 A
	501	12.4	256	268.4	68.9	49	7	6	5 B
	503	9.1	197	206.1	69.2	47.9	25	1	5 B
	505	8.3	112	120.3	68.7	49.3	2	13	6 A
97	303	2.3	34.1	36.4	68.0	43.1	84	2	4 B
	308	2.7	34.7	37.4	68.3	40.2	79	4	5 A
	502	6.8	43.3	50.1	66.3	44.8	91	3	6 B
115	308	44	24.8	68.8	67	27.2	2	5	4 A
	311	50.4	51.6	102	68.2	25.2	0	6	4 B
147	210	16.6	11.9	28.5	68.1	42.4	30	13	3 A
	304	3.6	6.8	10.4	67.7	40.4	22	36	4 B
	305	4.2	12.4	16.6	67.1	42	49	9	5 A
165	201	11.9	196	207.9	68.4	33.3	0	0	4 A
	202	5.3	151	156.3	68.0	34.5	0	0	3 B
	220	10	181	191	69.2	35	0	0	4 A
	308	1.8	154	155.8	68.7	35	0	0	5 B

the degree desired. If the pupils in one district are by reason of hereditary and environmental influences more susceptible to colds, then this school will unduly raise the sickness rate in the ventilation type within which the majority of its records fall.

Of the 12 schools used in the two studies, only one possessed all three examples of ventilation. In one other instance the three types were represented by two schools a block or so apart, one school having Type C and the other, Types A and B. In all other instances there were not more than two types represented within a school building, some buildings having A and B and others, B and C. The division of rooms is revealed in the table below.

One can readily appreciate by looking at the table how the results would be affected if, say, School 39 were given to very little sickness and School 147 to

TABLE XIII

DISTRIBUTION OF TEST ROOMS AMONG THE TWELVE SCHOOLS BY VENTILATION TYPE

SCHOOL	FIRST STUDY			SECOND STUDY		
	A	*B*	*C*	*A*	*B*	*C*
12	3	3	0	3	3	0
147	0	0	3	0	0	3
22	0	3	3	0	3	3
59	5	3	6	7	2	6
73	4	3	0	4	3	0
165	0	3	4	0	3	4
39	6	3	0	6	3	0
2 Bx.	0	3	3	0	3	3
33 Bx.				0	2	2
51 Bx.				0	0	2
97				0	3	3
115				0	3	2
Total	18	21	19	20	28	28

a great deal. In the summary of all rooms Type A, having 6 rooms in School 39 would have a low sickness rate, not because of ventilation, but because of its personnel, and Type C would be inclined to have a high rate, not because of ventilation but because of the numbers of children from School 147. Theoretically this influence should have been eliminated at the beginning, but actually this was found impossible.

The total respiratory illness rate including both absentees and those present in each school is shown in Table XIV.

TABLE XIV

TOTAL RESPIRATORY ILLNESS RATES BY SCHOOLS

SCHOOL	FIRST STUDY	SECOND STUDY
97	—	46.7
22	100.3	13.6
12 & 147	31.1	27.9
73	37.4	44.2
51 Bx.	—	106.4
59	103.1	193.3
39	12.6	51.6
2 Bx.	55.9	24.2
165	77.9	123.3
33 Bx.	—	92.6

A considerable variation is seen in the illness rates. Schools 59 and 165 are relatively high in both studies. Schools 12, 147 and 73 are low in both. School 22 is high in the first study and extremely low in the second.

We may examine the effect of ventilation apart from these extraneous influences mentioned first by inspecting the records of each school by itself and secondly by balancing the influence which each school exerts on the total.

In an effort to illustrate the comparison of illness rates within each school we have prepared Charts I and II, the former showing Types A and B and the latter, B and C. Both measures of illness among the absent and among those present are included. The frequency with which one ventilation type exceeds the other in amount of illness conveys an impression that is not brought out in the averages for each ventilation type.

In the comparison of the window ventilated rooms from the chart, Type B exceeds Type A in respiratory illness in nine instances. In the remaining seven instances Type A exceeds Type B. There is then no prevailing superiority of one type over another. It will be noted in the summary at the bottom of the chart, where the rates have been averaged, that Type B shows less re-

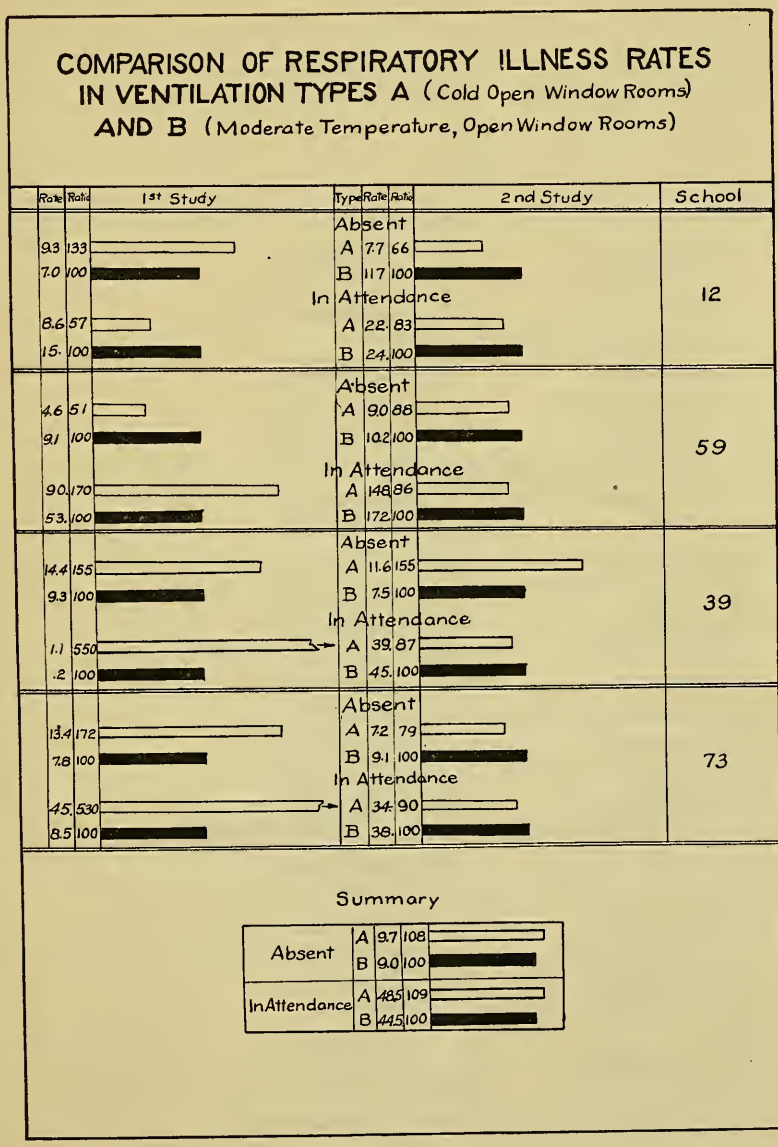


Chart I.

spiratory illness than A. This is due to the influence of several high rates in Type A. Incidentally this illustrates how an erroneous impression may be gained from averages alone.

In the comparison between Types B and C, the latter exceeds the former in respiratory illness in eighteen instances; whereas B exceeds C in only seven

instances. This result is much more significant than in the previous comparison. The averages of the rates are consistent with the tendency of the individual instances. With the new schools used in the second study included, the average for Type C exceeds B in both measures of respiratory illness. The same is true with the new schools omitted.

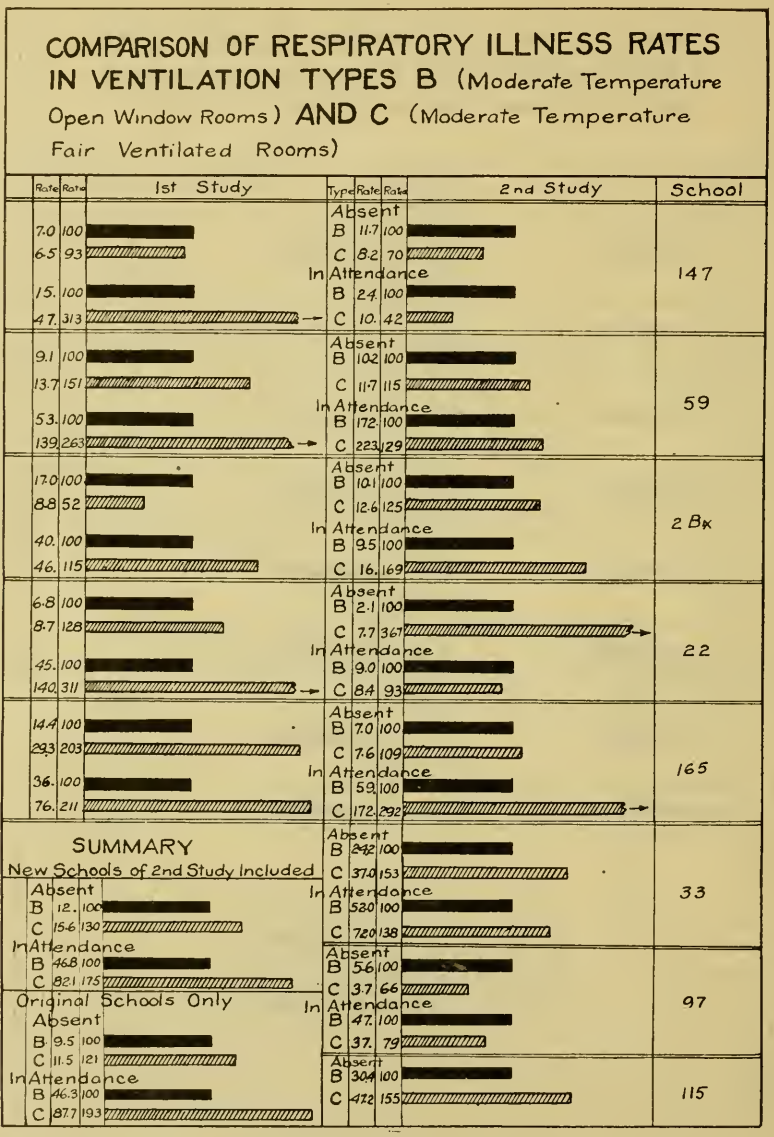


Chart II.

This analysis confirms what has been brought out previously—that the difference between Types A and B is insignificant; whereas, between B and C there is a distinct excess of illness in the fan ventilated rooms.

In School 59 all three types of ventilation are represented. We have in this instance a good measure of ventilation influences on pupils of the same

general characteristics. The fan ventilated rooms have the greatest respiratory illness in both studies. The relative positions of A and B are not the same in the two studies, the cold rooms having more illness in the first study and less in the second.

TABLE XV

RESPIRATORY ILLNESS RATES IN THREE VENTILATION TYPES AT SCHOOL 59

VENTILATION TYPE	FIRST STUDY			SECOND STUDY		
	SICKNESS CAUSING ABSENCE	SICKNESS IN SCHOOL	SUM	SICKNESS CAUSING ABSENCE	SICKNESS IN SCHOOL	SUM
A	4.6	90	94.6	9.0	148	157
B	9.1	53	62.1	10.2	172	182
C	13.7	139	152.7	11.7	223	235

The room temperature for each type averaged as follows:

A	58.8	58.7
B	65.4	61.9
C	68.2	69.1

The fan ventilated rooms were the warmest, exceeding the Type B rooms by 2.8 degrees in the first study and by 7.2 degrees in the second. These results are consistent in showing less illness in the window ventilated rooms.

In one other instance the three ventilation types are to be found divided between two schools within a block of each other and for all practical purposes the characteristics of the pupils are the same. The sickness rates for Schools 12 and 147 are shown in Table XVI.

TABLE XVI

RESPIRATORY ILLNESS RATES IN THREE VENTILATION TYPES AT SCHOOLS 12 AND 147

VENTILATION TYPE	FIRST STUDY			SECOND STUDY		
	SICKNESS CAUSING ABSENCE	SICKNESS IN SCHOOL	SUM	SICKNESS CAUSING ABSENCE	SICKNESS IN SCHOOL	SUM
A	9.3	8.6	17.9	7.7	22	29.7
B	7.0	15	22.0	11.7	24	35.7
C	6.5	47	53.5	8.2	10	18

(Temperature—1st Study A 60.5, B 66.6, C 67.3; 2nd Study, A 60.5, B 63.2, C 67.6.)

The fan ventilated rooms appear to better advantage in this instance, for illness is lowest in Type C in the second study. In the first study the total illness is greatest in the fan ventilated rooms, although the illness causing absence is the lowest of the three types.

The Type C rooms at School 59 were unusually well equipped with mechanical ventilation facilities. The air is humidified before entering the room, and the blowers are capably managed. The fan equipment at School 147 is older and the rooms were not thoroughly aerated at all times, and windows were frequently found open.

In view of the oft repeated assertion that humidification and air washing in combination with the plenum fan is from many standpoints a superior

form of ventilation, the figures of this study are of special interest. A modern form of mechanical ventilation with warm temperature is associated with more respiratory sickness than naturally ventilated rooms with gravity exhaust. On the other hand, fan ventilation, lacking many modern features, as in P. S. 147, is associated with less respiratory illness than naturally ventilated rooms. At P. S. 147 the temperature of the fan rooms was lower than at P. S. 59. Raising the temperature over 68 degrees would seem to be more disturbing to health than reducing the volume of air passing through the rooms.

The temperature of the A rooms in all instances was lower than those selected as B rooms. In general the C rooms were warmer than B, although there were some exceptions to this.

TABLE XVII

AVERAGE TEMPERATURE AND TOTAL RESPIRATORY ILLNESS RATES BY VENTILATION TYPES IN EACH SCHOOL

SCHOOL	VENTILATION TYPE	FIRST STUDY		SECOND STUDY	
		TEMP.	RATE	TEMP.	RATE
12	A	60.5	17.9	60.5	29.7
	B	66.6	22.0	63.2	35.7
147	C	67.3	53.5	67.6	18.2
39	A	57.2	15.5	57.7	50.6
	B	61.6	9.5	64.4	52.5
59	A	58.8	94.6	58.7	157
	B	65.4	62.1	61.9	182
	C	68.2	153	69.1	235
73	A	60.1	58.4	60.8	41.2
	B	65.3	16.3	66.6	47.1
2 Bx.	B	70.4	57.0	67.7	19.6
	C	69.1	54.8	66.1	28.6
22	B	69.6	51.8	67.7	11.1
	C	68.1	22.7	66.3	16.1
165	B	69.6	50.4	67.6	66.0
	C	70.9	105	68.6	180
33 Bx.	B	—		69.4	76.2
	C	—		70.6	109
115	B	—		67.6	30.4*
	C	"		67.6	47.2*
97	B			66.7	52.6
	C			67.6	40.7

*This is absence illness only.

Whenever temperatures are over 68 degrees, the warmer rooms have the greater sickness, regardless of whether Type B or C. When temperatures are below 68, the window rooms have less sickness in four instances and more sickness in two instances.

It may be pointed out in this connection that even where the temperatures of a fan and window room, as measured at the three-foot level, are identical, the window room is actually cooler, for the temperature at the floor level is always lower in the window rooms.

The second means of shedding light on the significance of the grand averages is by equalizing the influence of each school in each ventilation group. In doing this we have combined the two studies, omitting the schools that were not represented in both. Where there are 9 rooms at a school, 6 in Type A and 3 in Type B, we have reduced the number in the first type to three by averaging the two highest readings, the two lowest and the two intermediate. Where there are four readings, we have averaged the two highest and used the other two as they stand.*

We have illustrated in Tables XVIII and XIX the manner of making this computation by showing the selected rates used along with the original figures.

In Table XX will be found the averages of the rates both actual and ad-

TABLE XVIII

ACTUAL AND SELECTED RESPIRATORY ILLNESS RATES BY ROOMS
COMPARISON OF TYPES A AND B (BOTH STUDIES COMBINED)

	ABSENCE RATE				ILLNESS IN ATTENDANCE RATE			
	TYPE A		TYPE B		TYPE A		TYPE B	
SCHOOL	ACTUAL	SELECTED	ACTUAL	SELECTED	ACTUAL	SELECTED	ACTUAL	SELECTED
12	15.	15.	4.5	4.5	10.	10.	15.	15.
	8.6	8.6	11.3	11.3	3.	3.	14	14.
	5.0	5.0	5.1	5.1	16.	16.	17.	17.
	3.9	3.9	9.5	9.5	47.	47.	33.	33.
	8.1	8.1	15.9	15.9	14.	14.	31.	31.
	11.1	11.1	9.9	9.9	14.	14.	6.	6.
39	11.	11.	6.9	6.9	2.	2.	0.	0.
	11.		21.	21.	2.			
	14.	14.	1.4	1.4	2.	1.	1.	1.
	14				.6			
	21	19.			0	0	0	0
	17				0			
	6.9	6.8	10.9	10.9	65.	55.	34.	34.
	6.7		8.6	8.6	46			
	9.3	10.5	2.9	2.9	40	35.	43.	43.
	11.7				30			
	13.0	17.3			25.	21.	58.	58.
	21.6				18.			
59	.6	.6	15.1	15.1	210.	151.	61.	61.
	.6		10.9	10.9	91			
	8.2	8.4	1.5	1.5	72.	47.	91.	91.
	8.5				21.			
	5.8	5.8			74.	74.	15.	15.
	26.8		3.7	3.7	213.			
	9.2	18.	16.2	16.2	165	189.	187.	187.
	8.5			10.	124			
	8.	8.3			91	108	158.	158.
	4.3				144			
	3.0	3.8			150.	147.		173.
	4.				147.			
73	25.8	18.8	3.2	3.2	57.	57.	1.	1.
	11.5		10.2	10.2	34.	34.	1.	1.
	6.4	6.4	10.4	10.4	32.	32.	24.	24.
	10.8	10.8						
	11.6	8.9	9.7	9.7	42.	42.	23.	23.
	6.2		2.7	2.7	35.	35.	41.	41.
	6.1	6.1	16.	16.	18.	18.	51.	51.
	5.1	5.1						

*This might be done by averaging the two lowest or the two intermediate rates, letting the highest value stand. The difference, however, is too slight to alter the final result.

Table XIX

Actual and Selected Respiratory Illness Rates by Rooms
Comparison of Types B and C (Both Studies Combined)

School	Absence Rates				Illness in Attendance Rates			
	Type B		Type C		Type B		Type C	
	Actual	Selected	Actual	Selected	Actual	Selected	Actual	Selected
2 Bx.	3.1	3.1	13.	13.	36.	36.	64.	64.
	31.	31.	.8	.8	38.	38.	33.	33.
	16.4	16.4	13.3	13.3	47.	47.	47.	47.
	10.7	10.7	22.4	22.4	10.	10.	26	26.
	7.7	7.7	13.2	13.2	6.	6.	17.	17.
	11.6	11.6	1.3	1.3	12.	12.	4.	4.
22	5.7	5.7	7.0	7.0	7.	7.	4.	4.
	8.5	8.5	10.5	10.5	7.	7.	12	12.
	8.0	8.0	8.9	8.9	0	0	25.	25.
	0	0	4.8	4.8	0	0	6.	6.
	5.5	5.5	3.5	3.5	3.	3.	1.	1.
	.9	.9	14.4	14.4	25.	25.	18.	18.
59	15.1	15.1	17.9	17.4	61.	61.	188.	176
	10.9	10.9	16.9		91.	91.	163.	
	1.5	1.5	16.8	14.7	15.	15.	149.	145.
			12.6				140.	
			10.4	9.2			97.	97.
			8.0				97.	
	3.7	3.7	16.8	15.4	187.	187.	316	296.
	16.2	16.2	13.9		158.	158.	275.	
		10.	12.4	11.2		173.	256.	227.
			9.9				197.	
			9.1	8.7			182	147.
			8.3				112.	
12 &	4.5	4.5	8.4	8.4	15.	15.	46.	46.
147	11.3	11.3	1.5	1.5	14.	14.	73.	73.
	5.1	5.1	9.6	9.6	17.	17.	22.	22.
	9.5	9.5	16.6	16.6	33.	33.	12.	12.
	15.9	15.9	3.6	3.6	31.	31.	7.	7.
	9.9	9.9	4.2	4.2	6.	6.	12.	12.
165	10.4	10.4	37.0	36.1	21.	21.	156.	119.
	5.7	5.7	35.0		38.	38.	82.	
	26.4	26.4	34	34.	48.	48.	34.	34.
			12.	12.			34.	34.
	1.3	1.3	11.9	11.	99.	99.	196.	189.
	10.4	10.4	10.		56.	56.	181.	
	8.1	8.1	5.3	5.3	33.	33.	154.	154.
			1.8	1.8			151.	151.

justed. Where the school influence is thus equalized in each ventilation type the average illness rates are appreciably different from the uncorrected averages. In the comparison of Types A and B only those schools have been used which possessed both A and B rooms. A B room in a school not having

Table XX

Comparative Rates of Respiratory Illness with Uncorrected and Balanced Averages
(Both Studies Combined)

Ventilation Type	Absence Rate		Illness in Attendance Rate	
	Uncorrected	Balanced	Uncorrected	Balanced
A	10.0	9.6	57	48
B	9.0	9.1	39	45
B	9.4	9.4	38	43
C	12.0	11.1	94	73

an A room is omitted. Similarly, in the comparisons of B and C rooms, B rooms are omitted where there is lacking a C room in the same school.

Before correcting for number of rooms the absence rates for A and B were 10.0 and 9.0. After eliminating the abnormal influence of the schools with the most rooms, the rates are 9.6 and 9.1. In the first instance Type A was greater than B, largely because of the greater number of rooms at Schools 39 and 59, where the rates are higher.

The effect of eliminating the school influence is even more noticeable with the rates for illness in attendance. Without correction the rate for A was 57 and for B, 39, an appreciable difference. When the influence of each school has been equalized, the rates are 48 for A and 45 for B. In the former instance A exceeds B only because it possessed more rooms at P. S. 59, where the rates are high, and not because of any ventilation influence.

The corrected absence rates for Types B and C are 9.4 and 11.1, a difference of 1.7. Before the correction had been applied the rates were 9.4 and 12.0, a difference of 2.6. It was the greater number of rooms at P. S. 59, where the rates are high, that raised the average for Type C. When this influence is modified the difference between the two types is less.

A marked alteration is also produced in the rates for illness-in-attendance. Without the correction for number of rooms, the figure for B is 38 and for C, 94, a difference of 56. Eliminating the school influence the rates are 43 and 73, a difference of only 30. School 59 is largely to blame for the apparent wide difference in the types. With an equal number of rooms at each school we obtain a truer conception of the difference in ventilation types.

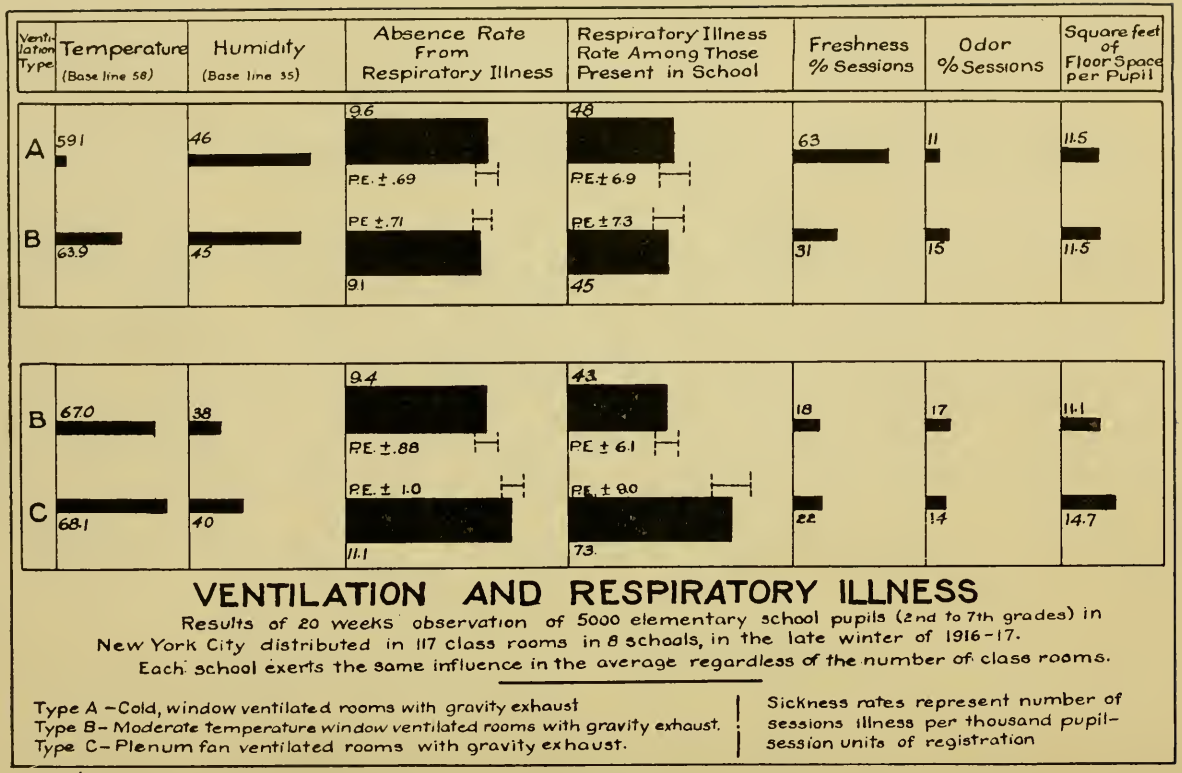
Having arrived at comparative figures which are believed to give a fairly accurate measure of the ventilation influence, we are confronted with the interpretation of these results. Is the difference of 0.5 between the absence rate in A and B significant, or is it a chance result which, if the experiment were repeated, would reverse itself? We can answer this question by determining the probable error of the averages. If the differences are statistically significant, they will represent at least three times the value of the probable error. If the differences are no greater than the probable error, then we cannot say that ventilation exercises an unmistakable effect on the health of these school children.

The formula for the probable error is

$$\text{P. E.} = 0.6745 \sqrt{\frac{\Sigma X^2}{n}}$$

The computation of the probable error is made by averaging the absence rates in each type: finding the deviation of each rate from the average; squaring each deviation; averaging these squares; determining the square root from this average; dividing this figure by the square root of the number of cases, which gives the standard deviation and finally multiplying this figure by the constant, 0.6745, which gives the probable error, or P. E.

The difference in the absence rates between Types A and B, 0.5, is less than the probable error, or approximately 0.7, and in consequence, is without significance. This means that the evidence is insufficient to prove that either



VENTILATION AND RESPIRATORY ILLNESS

Results of 20 weeks' observation of 5000 elementary school pupils (2nd to 7th grades) in New York City distributed in 117 class rooms in 8 schools, in the late winter of 1916-17.
Each school exerts the same influence in the average regardless of the number of class rooms.

Type A – Cold, window ventilated rooms with gravity exhaust
Type B – Moderate temperature window ventilated rooms with gravity exhaust.
Type C – Plenum fan ventilated rooms with gravity exhaust.

Sickness rates represent number of sessions illness per thousand pupil-session units of registration

Chart III.

type of ventilation is superior to the other in so far as respiratory illness is concerned.

Respiratory illness of a less severe nature and sufficient to keep children out of school is likewise, judging by the fact that the probable error exceeds the difference in rates, no different in a cold, window ventilated room with a temperature around 59 degrees than in a cool, window ventilated room whose temperature is in the neighborhood of 64 degrees. This finding is in agreement with the original computations for the entire group of rooms.

The differences between Types B and C are more marked. The higher probable error for absence rates, that is for Type C, is 1.0. The difference

TABLE XXI

PROBABLE ERROR OF RESPIRATORY SICKNESS RATES
(BOTH STUDIES COMBINED)

	DIFFERENCE BETWEEN VENTILATION TYPES A AND B	PROBABLE ERROR	DIFFERENCE BETWEEN VENTILATION TYPES B AND C	PROBABLE ERROR
Absence Rate	0.5	A ± .69 B ± .71	1.7	A ± .88 B ± 1.00
Sickness in Attendance Rate	3.0	A ± 6.9 B ± 7.3	30	A ± 6.1 B ± 9.0

(Note: Only schools used in both studies are included in the above.)

between the sickness rates is 1.7. While this difference is not greater than three times the probable error, the mere fact that it is greater suggests at least a tendency for Type C rooms to be more conducive to respiratory illness than those of Type B.

Minor respiratory illness insufficient to cause absence amounts to a rate of 43 in Type B rooms and to 73 in Type C. This is a difference of 30. The greater probable error is 9.0. The difference is thus more than three times the probable error and statistically may be regarded as significant. Interpreted in other words the system of fan ventilation representing Type C is more conducive to respiratory illness among school children than the window ventilation methods of Type B.

In Chart III are represented graphically the absence rates as well as other facts pertinent to the matter. The difference in average temperature between Type A and B rooms was 4.8 degrees. Relative humidity was almost identical, being 46 per cent in the A rooms and 45 in B. The A rooms were judged exceptionally fresh 63 per cent of the time as against 31 per cent for B. The air possessed a noticeable odor 11 per cent of the time in A and 15 per cent in B. The degree of congestion was the same in both types, namely: 11.5 square feet of floor space per pupil.

In the second comparison, the Type B rooms averaged 67.0 degrees temperature as against 68.1 for the C rooms, a difference of but 1.1 degrees. Relative humidity was 38 per cent in B and 40 per cent in C. The B rooms were judged exceptionally fresh 18 per cent of the time, the C rooms 22 per cent. Odor was noticeable 17 per cent of the sessions in B and only 14 in C.

The B rooms were appreciably more congested, the square feet of floor space per pupil being 11.1 as against 14.7 in the C rooms.

The following conclusions appear justified from the evidence:

1. Respiratory sickness is no greater in a window ventilated schoolroom kept around 59 degrees than it is in a room where temperature is 64.

2. Respiratory sickness is greater in fan ventilated rooms, such as are represented in this study, than in window ventilated rooms, even though there is not more than a degree difference in temperature, and the fan rooms are more spacious.

3. It is low temperature rather than chemical purity of the air which conveys the sensation of freshness.

DISCUSSION OF VENTILATION TYPES REPRESENTED IN THIS STUDY

The conclusions arrived at in discussing the relation of ventilation to colds raise the question as to whether all methods of school building ventilation by mechanical means are discredited by this test. This inference is of course unwarranted. The results of this study apply only to the types of ventilation here represented, a brief description of which will be given.

The selection of schools was made by the writer after a conference with Mr. Frank G. McCann, heating and ventilating engineer of the New York City Board of Education. Altogether over fifty schools were considered, and more than half of this number were visited in person by the writer.

There were many factors to weigh in making the selection. It was desired above all to choose schools possessing all three types of ventilation. As previously explained, this was found impossible except for one school. These conditions were nearly fulfilled in one other instance where the three types were found in two schools within a block or so of each other. For convenience it was desirable that the schools should be located within Manhattan and Bronx Boros. To represent this territory, selections were made in Lower Manhattan, Central Manhattan and Upper Manhattan and the Bronx. It was further desired that the ventilation methods should have already been in use for some time prior to the experiment, so that uniform operating conditions would be established. It was possible to adhere to this requirement in all but one school, 165, in the first study and all but four in the second. In these four, 165, 97, 115 and 33 Bx., window ventilation was arranged by blocking off the fan supply inlets to the rooms and by installing deflectors at the windows. The effort was made to select schools whose mechanical ventilation equipment was in good condition and in capable hands. Lastly it was essential that the principal of the school should be in sympathy with the objects of the study.

Schools 12, 147 and 22 were located in lower Manhattan, the first on Madison and Jackson Streets; the second on Henry and Gouverneur, and the third on Stanton and Sheriff. Schools 59 and 73 were in Central Manhattan, the former on 57th Street near Third Avenue, the latter on 46th Street near

Third Avenue. School 165 was on 109th Street near Broadway; 39 on 126th street near Second Avenue; 2 Bx. on 169th Street near Third Avenue. The schools added in the second study were 97 on Mangin Street between Stanton and Houston, in the lower East Side; 115 on 176th Street near Audobon Avenue; 33 Bx. on 184th Street and Jerome Avenue, Bronx; 51 Bx. on Trinity and Jackson Avenues, Bronx.

The date of erection of each building, as well as the type of building ventilation is shown in Table XXII:

TABLE XXII

SCHOOL	DATE OF ERECTION AND ADDITIONS	AERATION	HEAT CONTROL	REMARKS
12	1908	Window and Grav. Exhaust	Thermostatic	
147	1898	Plenum Fan and Grav. Exh.	"	
22	1843-1873-1891-1902	" " " " "	"	
73	1880-1902	Windows and Grav. Exhaust	Manual	
59	1871-1904-1908	Plenum Fan and Grav. Exh.	Thermostatic	Also air washer
165	1898-1905	" " " " "	"	
39	1903	Windows and Grav. Exh.	"	
2 Bx.	1874-1886-1902	Plenum Fan and Grav. Exh.	"	
51 Bx.	1915	Plenum and Exhaust Fans*	"	Also air washer*
33 Bx.	1899	Plenum Fan and Grav. Exh.	"	
115	1914	Plenum Fan and Grav. Exh.	"	Also humidifying fan
97	1915	" " " " "	"	Also air washer

*This refers only to the two rooms used in the study.

The window ventilated rooms had direct radiation beneath the windows. In the first study there were no deflectors except at School 73. In the second study deflectors were provided in all rooms of Type A and B. All of these rooms had gravity exhaust openings to permit air circulation. It is best that these openings be in the inside wall opposite the windows. This arrangement did not exist in many rooms, the openings being in walls adjacent to the windows and frequently so small in size as to be really of little service in keeping the room well aerated. Direct radiation was thermostatically controlled in all cases save in School 73, where it was manually controlled.

The mechanical ventilation consisted usually of plenum fans, air being driven into the classrooms near the ceiling and leaving through gravity exhaust openings near the floor. These rooms were also provided with direct radiation under thermostatic control. A check on the ventilation was had by means of ribbons on the inlet. These were observed by the nurses, who could thus tell in a rough way the efficiency of the blowers.

The system at School 147 gave a weak and irregular air flow to the three classrooms during the first study, and windows were frequently opened. This condition was greatly improved in the second study.

School 22 had a plenum fan system in the new wing. The air flow in the rooms was continuous and pronounced, and windows were rarely opened. Anemometer readings at the register face made on January 8, 1917, showed 1640 cubic feet per minute in Room 402, 1960 in 403 and 1620 in Room 404.

School 59 had a plenum fan system in the new addition built in 1908. This consisted of two blowers and an air washer. This equipment was in most capable

hands, and the rooms were at all times well flushed with humidified and washed air. Windows were always kept closed. On January 15, 1917, anemometer measurements showed the following air flow in cubic feet per minute: Room 203—1400, 205—1300, 206—1740, 501—1150, 503—1380, 505—760. During both studies there was continuous and pronounced flow in all rooms.

School 165 had a plenum fan system with gravity exhaust which proved inadequate for the rooms used in the study. At times air flow was ample, again deficient. Conditions were better in the second study.

School 2 Bx. consisted of an old and new section, the latter built in 1902. This section contained the plenum fan ventilating equipment with gravity exhaust. Air flow was fairly continuous and pronounced.

The orientation of the classrooms varied somewhat in the three types, the A rooms having a greater amount of southern exposure.

TABLE XXIII

ORIENTATION OF CLASSROOMS IN FIRST STUDY

VENTILATION TYPE	N., N. E., N. W.	W.	S., S. E., S. W.	E.
A	5	0	12	1
B	9	3	4	5
C	9	5	3	2

RESULTS IN NEWER SCHOOLS ADDED IN SECOND STUDY

When this study was begun, there were no schools erected within two or three years which could be used. In the second study we were enabled to add four schools, three of which had just been opened to pupils within the year. School 51 Bx. contained two rooms in which the Ventilation Commission was making studies on the effect of humidification, both being ventilated by plenum and exhaust fans. These results were included in the grand totals, but of course they do not furnish us with a comparison of the types forming the basis of this study. The respiratory sickness rates were higher in the humidified room. Temperature was about the same in both. Odor was frequently noticeable in the humidified room.

TABLE XXIV

RESPIRATORY ILLNESS IN SCHOOL 51

VENTILATION TYPE	ABSENCE RATE	SICKNESS IN ATTENDANCE RATE	TOTAL RESP. SICKNESS RATE	TEMPERATURE	RELATIVE HUMIDITY	PER CENT SESSIONS ESP. FRESH	PER CENT SESSIONS ODOROUS
Humidified	4.0	148.	152.	67.6	44	0	39
Not Humidified	14.7	50.	64.7	67.4	29	0	2

School 33 was an older building, but because of work already in progress there by the Ventilation Commission, the sickness records were also collected and added to the grand totals of this study. Ventilation was by

means of plenum fans and gravity exhaust. The fan inlets were blocked off in the Type B rooms and deflectors placed at the windows. The respiratory sickness rates were less in the two window ventilated rooms than in the two of Type C. The fan rooms were slightly warmer but less odorous.

TABLE XXV

RESPIRATORY ILLNESS IN SCHOOL 33

VENTILATION TYPE	ABSENCE RATE	SICKNESS IN ATTENDANCE RATE	TOTAL RESP. SICKNESS RATE	TEMPERATURE	RELATIVE HUMIDITY	PER CENT SESSIONS ESP. FRESH	PER CENT SESSIONS ODOROUS
B	24.2	52	76.2	69.4	34	1	15
C	37.0	72	109.0	70.6	30	2	3

School 97 was just completed in 1915 and was equipped with plenum fans and gravity exhaust, the air being washed and humidified before entering the rooms. Three rooms were chosen to represent each of Type B and C. The respiratory sickness rates were the lowest here of all the schools. Sickness was less in the fan ventilated rooms than in the window rooms. The fan rooms were a degree warmer and were much better aerated.

TABLE XXVI

RESPIRATORY ILLNESS IN SCHOOL 97

VENTILATION TYPE	ABSENCE RATE	SICKNESS IN ATTENDANCE RATE	TOTAL RESP. SICKNESS RATE	TEMPERATURE	RELATIVE HUMIDITY	PER CENT SESSIONS ESP. FRESH	PER CENT SESSIONS ODOROUS
B	5.6	47	52.6	66.7	42	49	32
C	3.7	37	40.7	67.6	43	85	3

The location of this school was along the East River, and across the street was a large stable whose odors were frequently wafted over to the school at times of east wind. This interfered with the free use of the windows. The fan ventilated rooms were not troubled by these odors. One of the three window rooms was on an enclosed court which also cut down free air circulation. The experience at this school was very suggestive. Here was an illustration where fan ventilation provided a more satisfactory result than window ventilation. Schools with similar locations in the neighborhood of noxious odors are evidently better served by indirect washed air than by taking air direct from the windows. The teacher of one window room was well satisfied and much preferred it to the fan ventilation of the building. The majority opinion, however, favored the fan rooms.

School 115, erected in 1914, was equipped with plenum fans, a humidifying pan and gravity exhaust ducts. Air flow was at all times ample. Little or no use was made of the humidifying pan. Respiratory sickness was greater in the fan ventilated rooms.

TABLE XXVII

RESPIRATORY ILLNESS AT SCHOOL 115

VENTILATION TYPE	ABSENCE RATE	TEMPERATURE	RELATIVE HUMIDITY	PER CENT SESSIONS ESP. FRESH	PER CENT SESSIONS ODOROUS
B	30.4	67.6	28.	2	3
C	47.2	67.6	26.	1	6

(Note: The comparative data on sickness among pupils in School are not available for this school.)

A great deal of dissatisfaction with the fan ventilation existed among the teachers in this school. Complaints of dryness and drafts were common. The window rooms were by far the more comfortable.

In the three schools added in the second study, where Types B and C were studied, the window rooms showed less respiratory illness in two, and more in one. This supports the findings in the other schools.

In view of the favorable showing for fan ventilation in a very modern school with humidification such as 97, it may appear that the results of this study do not apply to installations of the latest design. It is true that we cannot generalize too widely in the matter, but on the other hand, School 59 possessed very modern equipment and was operated in every way as perfectly as 97, and yet the sickness rates here were higher than in the other rooms crudely equipped for window ventilation.

The buildings used were representative of what existed in New York City at the time. All were not of the very latest construction; nor were all of ancient pattern and design. All types were represented. The buildings were equipped and built with plenum fan ventilating systems. These systems were not ideal. They possessed faults as judged from the ventilating engineer's viewpoint of the year 1915.

The rooms fitted up for window ventilation were not built for this purpose. They were altered for the plan in mind. In no instance were the facilities complete.

As a comparison of average fan ventilation in New York City school buildings and ventilation of the same buildings without fans, the present study is entirely fair. If either type of room is lacking in its equipment, it is the window ventilated rooms which labored under the greater handicap.

METHODS OF RECORD TAKING

A word may be devoted here to the method of collecting records.

Each classroom was visited morning and afternoon. In the morning a record was made of the pupils absent and of the pupils in attendance who exhibited signs of a cold. The cause of absence was ascertained by a visit to the home. If a physician were in attendance his diagnosis was accepted. If no physician were in attendance, the nurse diagnosed the case, and when in doubt, her opinion was checked by a medical inspector. Many absences were not due to illness, as the subsequent records will indicate.

The diagnosis of minor illness among pupils in school was made by the

nurse. Many pupils with symptoms of a cold were pointed out to the nurse by the teachers.

At the beginning of the afternoon session the nurse again visited each room to ascertain absences, and the causes were determined in the usual manner. No effort was made at this time to determine illnesses among those present. A child recorded as having coryza in the morning was credited with the same affection in the afternoon if he or she were present in school.

In addition to the routine described above, the nurse entered each classroom at about 10:30 A.M. and 2:15 P.M., or just prior to the midsession aeration of the room, and recorded her impressions of the air conditions and made determinations of temperature and humidity with a sling psychrometer. The actual procedure was to enter the room, walk down the side aisle to the rear and thence up the middle aisle to the center of the room. The impression of odor was then recorded in terms of the scale given below. Next in order were recorded the sensations of temperature, moisture and air motion in terms as shown. The psychrometer was then swung at a level of about three to four feet from the floor, the wet bulb having been moistened from a small bottle of water carried for the purpose, and both wet and dry bulb readings noted.

VOTING SCALES OF SENSE IMPRESSIONS

ODOR		TEMPERATURE		MOISTURE		AIR MOTION	
Exceptionally fresh	1	Too warm	40	Moist	B	Dead	R
Odor absent	2	Satisfactory	30	Neutral	C	Bet. R & T.	S
Odor	3	Cool	20	Dry	D	Breezy or drafty	T

Before departing, the nurse made notations of the position of windows, whether open or closed, position of door and transom and activity of flag attached to the inlet register in the fan ventilated rooms.

Prior to the beginning of the study the nurses were carefully rehearsed in their duties and were given demonstrations in the use of the sling psychrometer.

The diagnosing of respiratory illness was frequently checked up by medical school inspectors and the supervising physician of the study, Dr. Leopold Marcus.

For several weeks during the second study all diagnoses were made by medical inspectors. Their opinions fully confirmed the interpretations made by the nurses and verified the casual inspections of physicians made prior to this time.

Respiratory illness is responsible for 19 per cent of absences from school; illness other than respiratory (including, however, the acute contagious diseases) 37 per cent; and causes other than illness 44 per cent.

THE SCHOOL PERSONNEL AND RESPIRATORY ILLNESS

The personnel of the pupils is a marked factor in determining the respiratory illness rates distinct from environmental influences. This was recognized at the outset, and an attempt, but partially successful, was made to equalize

this influence among the three ventilation types. Some schools were high in respiratory illness in both studies, while others were low in both.

Considering the total respiratory illness rates for both studies, Schools 12 and 147 had the lowest figures. These schools are on the lower East Side in the heart of the Russian-Jewish districts. The buildings are old. The average temperature was around 64 degrees. These two schools may be contrasted with Schools 165 and 115, which were located in very good neighborhoods and were attended by native born children of well-to-do parents. Both are of more recent construction than 12 and 147, P. S. 115 having been erected in 1914. In spite of environmental and social advantages, the upper Manhattan schools had high rates from respiratory illness.

In general, the schools located in congested districts and attended by pupils of inferior economic and sanitary status had less illness than those located in the better class neighborhoods.

Averaging the rates by social and economic status, the above facts stand out clearly.

SOCIAL AND ECONOMIC STATUS	SCHOOLS	RESPIRATORY ILLNESS RATES AMONG THOSE	
		ABSENT	IN ATTENDANCE
Very good	165, 115, 33	34.7	78
Good	59, 2 Bx., 51 Bx.	10.6	85
Poor	12, 147, 22, 97, 73	7.6	35.4
Very Poor	39	10.8	21.6

An explanation of this unexpected result is not easy to give. It prompts the query—Does prosperity undermine health and are our children of superior social status coddled to their detriment?

It is entirely possible that the children in the poorer districts acquire a more specific immunity by reason of their congested manner of living. It has been shown by Vaughan and the writer that the city boy made a hardier soldier in our army camps in 1917 and 1918 and was less subject to disease than the country boy.*

It is also possible that the pupils in the poorer neighborhoods become "hardened" by slight exposure to cold, the body becoming less sensitive to environmental changes. Overheating and overeating are drawbacks to which this class is less familiar than their more fortunate schoolmates. In many respects material success converts a man into a less perfect physiologic machine. As the battle with the elements becomes less severe, the stimulation to physiological combativeness wanes. Lack of exercise, complex food as distinguished from simple coarse food, and life in uniformly and highly heated buildings without question weakens the body physically. In these statements may be found the explanation of this peculiar distribution of the ordinary forms of respiratory illness.

In view of the fact that the Type C rooms had more girls than the others, the question arises as to whether this would not account for the greater ill-

*"Communicable Disease in the National Guard and National Army of the United States During the Six Months from September 29, 1917, to March 29, 1918." By Col. V. C. Vaughan and Capt. T. G. T. Palmer, Jour. of Laboratory and Clinical Medicine, Vol. III, No. II, August, 1918. Pages 693-698.

ness.** This presupposes that girls are more susceptible to colds than boys, a supposition for which there is no justification so far as we know. There is no indication of this in the present study.

In the first study, P. S. 165, Type C had the highest respiratory absence rate, yet only 28% of the pupils were girls. The next highest rate was at P. S. 2, Bronx, Type B, where 50% of the pupils were girls. The third highest rate was at P. S. 165, Type B, where all the pupils were boys.

P. S. 2, Bronx, Type C, had high illness rates in the second study and yet only one-third of the pupils were girls.

P. S. 12 and 147 had low rates in both studies and the ratio of girls to boys was four to one in the first study and three to one in the second.

TYPES OF RESPIRATORY ILLNESS

Lacking the diagnosis of a medical man as to the specific type of respiratory illness in all instances of this study, we cannot publish these facts with any degree of certainty. However, we submit the statements of the nurses, which it will be remembered were frequently checked by the medical school inspectors.

The most prevalent form of respiratory illness causing absence was tonsillitis, which amounted to 32 per cent of the total. Slightly less prevalent were coryza (25%) and bronchitis (22%). Laryngitis and pharyngitis were less frequently mentioned.

Of the illnesses among those present in school, coryza representing 62% of the total, is the most prominent. Bronchitis stands second with 20% and laryngitis third with 10%.

Tonsillitis is especially prevalent in the Type C rooms. Other affections are greater in Type C, but no one affection seems to be characteristic of any ventilation type.

Illness other than those listed under the term "respiratory illness" were due to a great many causes. Diphtheria, scarlet fever, measles and chickenpox were responsible for a small amount of absence, but absence from these causes combined amounts to less than that due to tonsillitis alone. In the first study the indefinite term "sickness" was given as responsible for more absence than any single cause. More specific terms were used in the second study. Headache was a frequent cause of absence, being mentioned most frequently in the Type C rooms. Appendicitis was responsible for a number of absences. A miscellaneous group of innumerable causes makes up the bulk of the absence causes. No particular form of illness seems to characterize any ventilation type.

WEATHER AND RESPIRATORY ILLNESS

Although aside from the ventilation question it is of interest to note the fluctuations in respiratory illness from week to week and the corresponding changes in weather. From the preceding pages it is evident that the indoor

**The percentage of girls in Type C was 60 in the first study and 54 per cent in the second. The figures for Type B were 37 and 31 and for A, 41 and 49.

atmosphere has an influence on health. By combining the records of all schools it will be possible to follow the seasonal change in respiratory illness.

In Chart IV we have shown the sickness rate in each type of ventilation by weeks along with the room temperature and relative humidity. The data for Schools 97, 115 and 51 Bx. are omitted, as records were available only

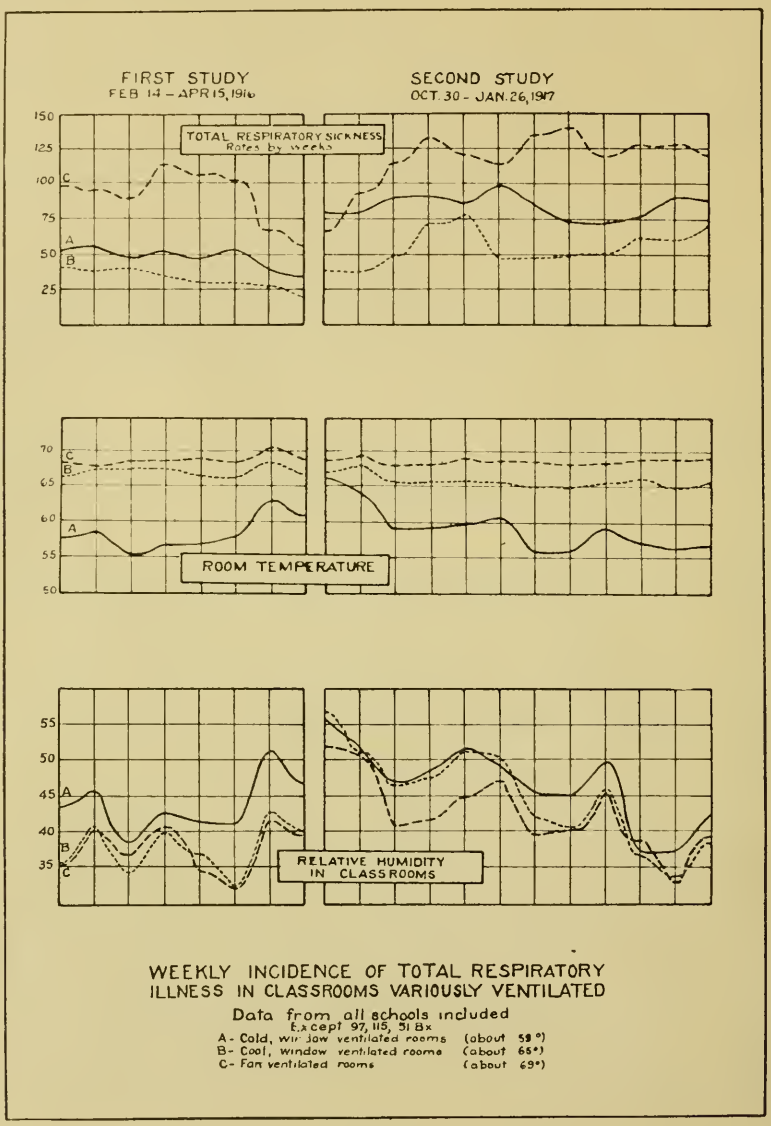


Chart IV.

during the last seven weeks of the second study. The fan ventilation group shows the greatest amount, and the window ventilated, moderate temperature, the lowest amount of respiratory illness throughout.

Respiratory illness declines from February to April although the fan ventilated rooms show the highest point during the middle of March. Colds

are at a higher level in October than they are in April. In the Type C and B rooms colds increase abruptly during the first 5 weeks in the Autumn. Type C then holds this level. The B rooms fall off and do not rise again until January. Colds in the Type A rooms increase gradually from October till

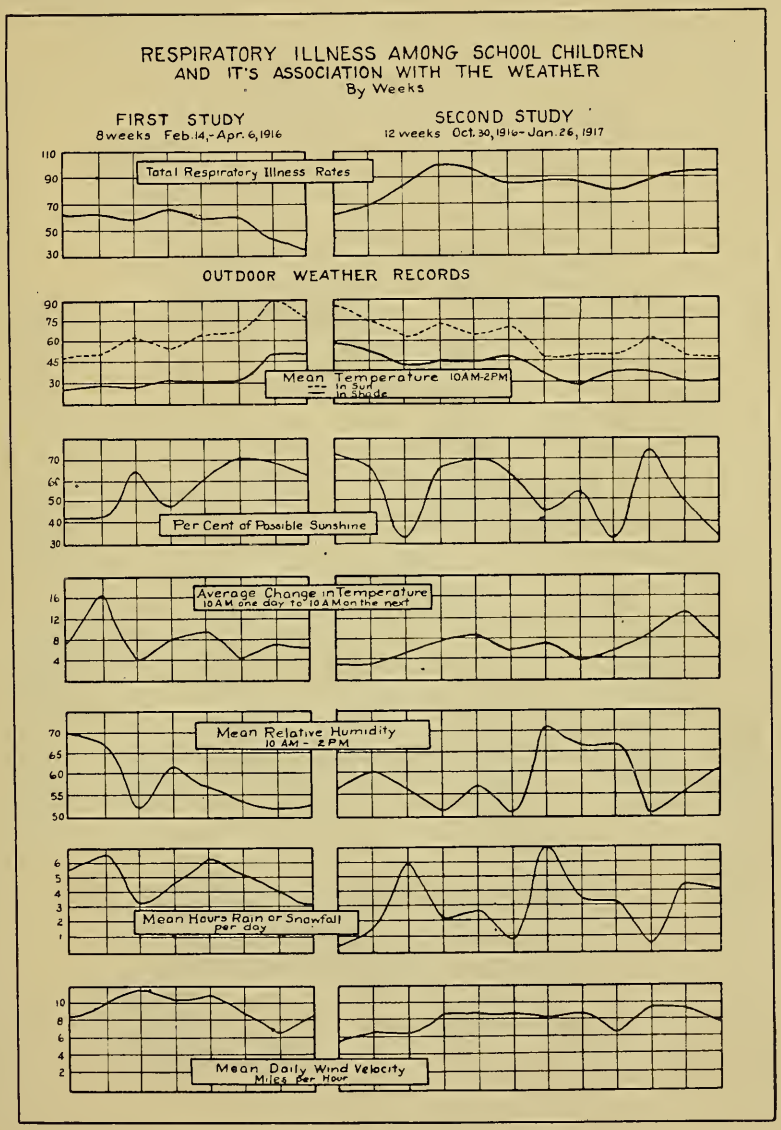


Chart V.

the first week in December. From this point they decline only to rise again the latter part of January.

Room temperature in the fan ventilated rooms is the most uniform, keeping quite constantly between 68 and 69 degrees. In the window rooms Type B, temperature has a slightly wider variation, from 65 to 68 degrees, but is consistently below Type C. In Type A rooms we note a wide variation,

from 55 to 66. During February and March these rooms run between 50 and 60, and this is true also in December and January. In April and November the temperature is from 60 to 65.

Relative humidity is greatest in the A rooms. It is lowest in March and January. As will be seen from a later chart, humidity is influenced mostly by outdoor temperature and next to that by outdoor moisture.

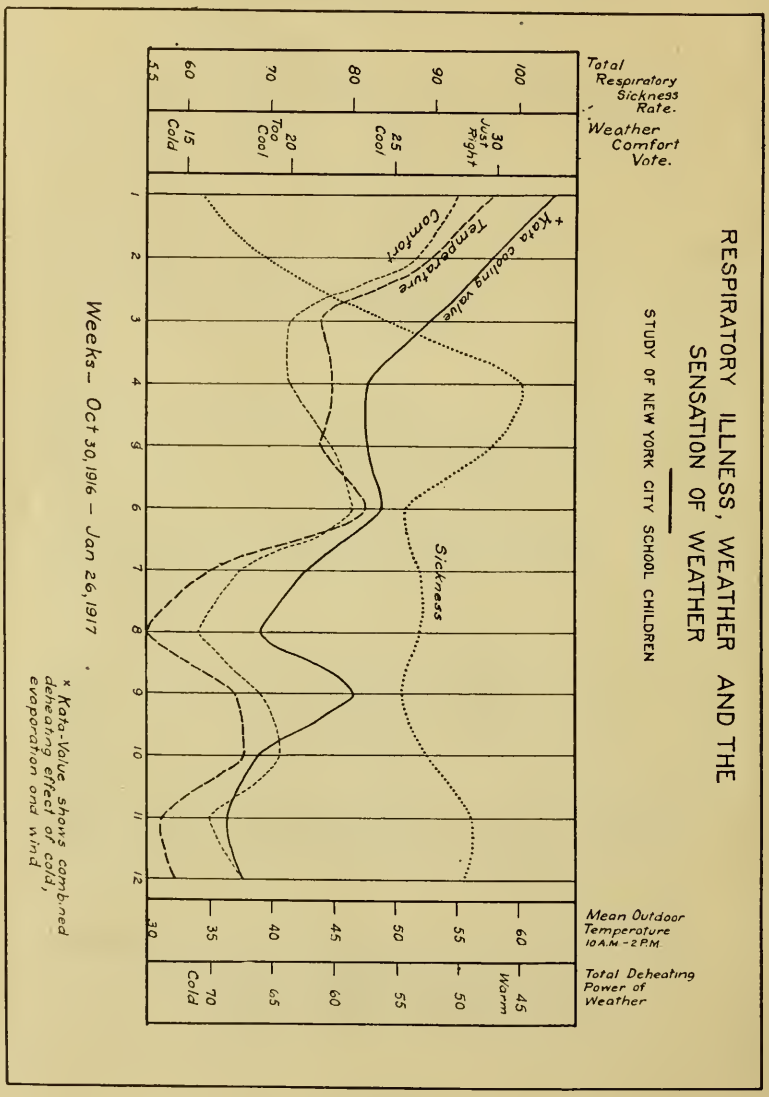


Chart VI.

The general points to be noted from this chart are that colds are more common in fall than in late winter, that even though the room temperature and humidity in Types B and C are quite similar, there is an appreciable difference in the prevalence of colds, and finally that the course of respiratory illness from week to week is guided mainly by influences other than the temperature and humidity of the classroom.

That outdoor weather bears a close relationship to colds is illustrated by the various graphs on Chart V. Far overshadowing other weather influences is temperature. In the spring, colds decrease as the weather becomes warmer. In the fall, oncoming cold weather is coincident with increasing respiratory affections.

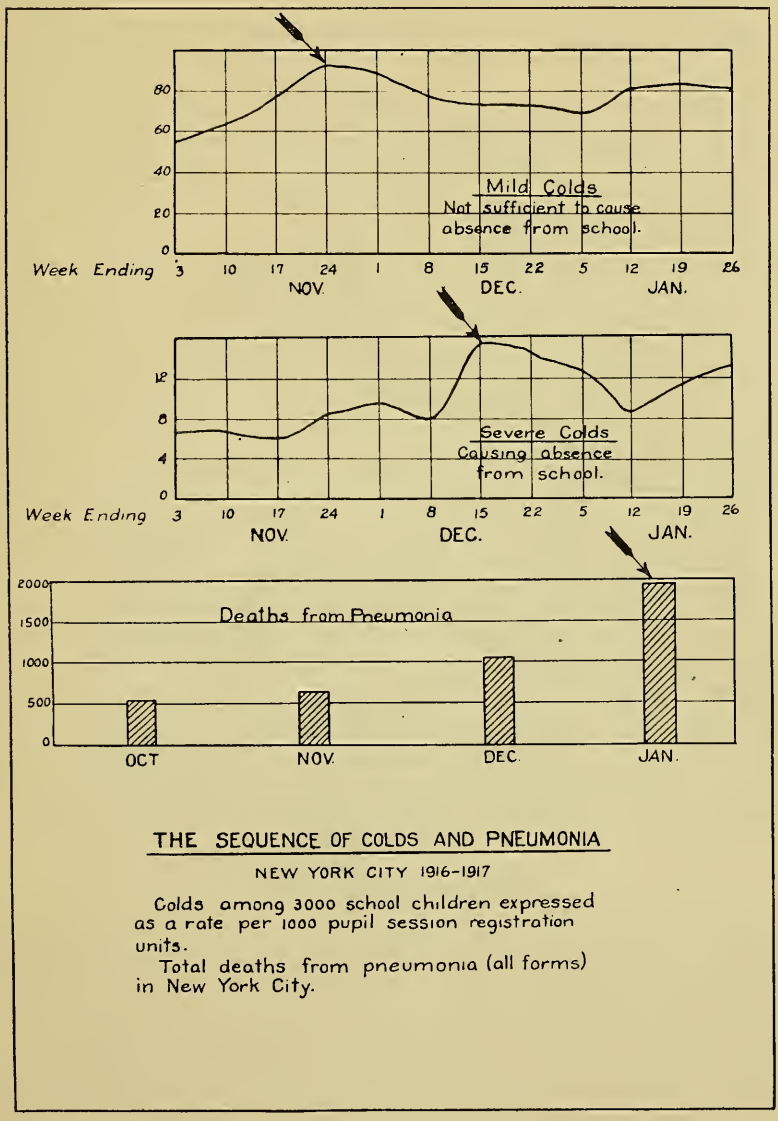


Chart VII.

What is understood as changeable weather does not have marked influence on colds. The third week in February shows an extreme daily change in temperature with no accompanying increase in colds.

Relative humidity shows wide variations from week to week without corre-

sponding undulations in the sickness curve. The late winter is more blustery than the fall, and yet colds are less numerous in the windy season.

Temperature and colds are most closely related. Is it temperature per se or the total chilling effect of all weather elements combined? The formula derived by Dr. Leonard Hill of England from his instrument known as the kata-thermometer permits us to sum up in a single expression the combined deheating effect of cold, evaporation and wind action.* From the mean daily outdoor temperature, vapor pressure and wind velocity we have computed the mean "total H" or total deheating power of the elements. This graph has been placed alongside curves for respiratory illness in the second study, and mean temperature and a fourth curve labelled "comfort." The comfort vote is a summary of the recorded daily impressions of the temperature feeling of the weather, as judged by three members of the staff of the Ventilation Commission.

The kata and temperature curves closely parallel each other. In some respects the kata curve is more closely associated with the rise and fall of illness than the temperature curve. Thus, the kata curve shows increasing cold for the first four weeks corresponding to increasing illness. The temperature curve shows no increase in cold in the fourth week over the third.

Illness falls off as the temperature stabilizes. In the 7th week temperature again descends, and sickness picks up. The 10th week is much colder as judged by the kata reading although the temperature is no lower. There is however, very low humidity and high wind velocity, which are heat extractors. These data suggest that it is the total chilling effect of the atmosphere rather than low temperature alone that is conducive to illness.

The curve of outdoor temperature comfort closely parallels the temperature curve, more so than the kata curve.

The sequence of mild colds in November, followed by heavier colds in December and then by pneumonia in midwinter, is strongly suggestive of a progressive weakening of vitality. Our mid-winter pneumonia peak is thus the result of attrition of vital resistance caused, among other things, by acute respiratory affections in the months preceding.

SUMMARY AND CONCLUSIONS

From the results of this study there appears to be something inherent in the indirect method of ventilating schoolrooms by means of forced draught and gravity exhaust, as practiced in this study, that is productive of respiratory affections, something which is not present in rooms ventilated with windows and gravity exhaust. What these unfavorable elements are is not entirely clear. Higher temperature is one. Uniformity of temperature and air flow is another. Uniformity is characteristic of the fan ventilated room. In an unvarying atmosphere the occupants miss that pleasant stimulating effect. Evidently the absence of this quality affects health adversely as well as comfort.

*"The Measurement of the Rate of Heat loss at Body Temperature by Convection, Radiation and Evaporation." By Leonard Hill, F. R. S., O. W. Griffith and Martin Flack, Philosophical Transactions of the Royal Society of London. Series B. Vol. 207, pgs. 183-220. 1916.

The temperature of window ventilated schoolrooms may be reduced as low as 59 degrees without increasing the prevalence of colds.

It must not be inferred that window ventilation as represented in this study was uniformly satisfactory. It was not. As a rule the rooms exposed on the east do not fare as well as others. Ample exhaust openings are better than those of small area. There is the matter of location of outlets with respect to the windows, location, size and control of direct radiation, window deflectors, etc., which affect the success of window ventilation. All of these factors must be studied.

In spite of our inadequate knowledge of window ventilation at its best, the fact remains that the window rooms of this study, even though of crude arrangement and not built originally for the purpose, competed on favorable terms, from a hygienic and aesthetic standpoint, with the most elaborate and costly fan and duct equipment. The tendency in the past twenty years has been away from natural and toward mechanical ventilation. The time and effort of the heating and ventilating engineer has been directed toward the perfecting of mechanical means for aerating buildings. What would the same amount of effort have yielded if expended on the development of natural ventilation? Possibly something of great value and at less expense.

Because window ventilation is practicable for the ordinary schoolroom, it does not follow that the assembly room, the theatre and other places seating several hundred people can also be dealt with in this manner. Each type of enclosure must be handled as a distinct problem. Natural ventilation has its limitations. That the schoolroom is not beyond these limitations is the indication of this study.

The factors which, above all others, promote comfort, health and efficiency are coolness and fluctuating air motion. If the teacher maintains her classroom in a changing condition, without draughts, between 64 and 70 degrees, with the mean lying nearer the lower figure, it matters little from a practical standpoint what the other measurements of ventilation indicate. To this standard the room properly equipped with window ventilation and gravity exhaust, can readily conform.

In its quantitative effect on respiratory illness school ventilation is of much less moment than the outdoor weather influence. Respiratory affections increase with the onset of cold weather. They diminish with the advent of mild weather in the spring. Wind and humidity accentuate the temperature influence. Sunlight exerts at least a warming influence sufficient to modify the unfavorable effect of cold. Abrupt changes in temperature do not influence respiratory illness as much as one might expect from everyday experience.

The sanitarian is interested in the prevention of the tremendous increase in the mortality from the pneumonias, which occurs in cold weather. If it is possible to mitigate the unfavorable weather effect by the proper regulation of the indoor atmosphere, it behooves the public health fraternity to bend every effort toward this goal. The problem is an alluring one. The results of this school study hold forth much promise in this direction.

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